PROC. ENTOMOL. SOC. WASH.
109(3), 2007, pp. 684–688

TAXONOMY AND ECOLOGY OF THE PITCHER PLANT MOSQUITO, *WYEOMYIA SMITHII* (COQUILLETT) (DIPTERA: CULICIDAE), IN MISSISSIPPI

JEROME GODDARD, GRETCHEN WAGGY, WENDY C. VARNDO, AND BRUCE A. HARRISON

(JG, WCV) Mississippi Department of Health, P.O. Box 1700, Jackson, MS, 39215, U.S.A. (e-mail: jgoddard@msdh.state.ms.us); (GW) Grand Bay National Estuarine Research Reserve, 6005 Bayou Heron Rd., Moss Point, MS 39562, U.S.A.; (BAH) North Carolina Department of Environment and Natural Resources, 585 Waughtown St., Winston-Salem, NC 27107, U.S.A.

Abstract.—During 2005, a population of the Gulf Coast race of *Wyeomyia smithii* (Coquilett) was studied in the purple pitcher plant, *Sarracenia purpurea* L. and one hybrid plant in the Grand Bay National Wildlife Refuge located in extreme southeastern Mississippi. Twenty-nine larval specimens of *Wy. smithii* were collected during this study from two clusters of plants approximately 100 m apart. A short review is provided of the changing taxonomic concept for *Wy. smithii* in the United States. Mississippi populations of *Wy. smithii* represent a Gulf Coast race of the species, but current evidence does not support providing a subspecies name for this race. Also provided are ecological observations of the affects of a controlled burn of the pitcher plant field as well as the storm surge caused by Hurricane Katrina on the plants and *Wy. smithii* population densities.

Key Words: *Wyeomyia smithii*, pitcher plant mosquito, ecology, taxonomy

Wyeomyia smithii (Coquillett) is one of only three species of *Wyeomyia* Theobald in North America that are phytotelmic. *Wyeomyia vanduzeei* Dyar and Knab from Florida, and *Wy. mitchellii* (Theobald) from Florida and southern Georgia, are found in bromeliads, while *Wy. smithii* is associated with the purple pitcher plant, *Sarracenia purpurea* L. (Sarraceniaceae), from the Gulf Coast northward into Canada. Recently, the southern form of the pitcher plant *S. purpurea* was proposed to be a new species named *S. rosea* (Naczi and Soper 1999); however, we are retaining the name *S. purpurea* for this study. According to Bradshaw (1983), *Wy. smithii* may be found occasionally in other pitcher plants such as *S. flava* L., *S. leucophylla* Rafinesque, *S. rubra* Walt., and *S. alata* Wood, but cannot overwinter in these other species because the leaves die back during winter. Further, *Wy. smithii* larvae also may be found in hybrids between *S. purpurea* and *S. flava*, *S. alata*, *S. leucophylla*, and others, and in warm southern areas they may survive in the hybrid leaves through the winter months (Bradshaw 1983).

No major mosquito taxonomic publications list *Wy. smithii* as occurring in Mississippi (Carpenter and LaCasse 1955, King et al. 1960, Darsie and Ward 2005); however, papers published in the journal *Evolution* present Mississippi collection data (Bradshaw and Lounibos

1977, Armbruster et al. 1998). The species is rare in Mississippi and little is known of its habitat, distribution, and ecology in the state. In this paper, we present ecological, biological, and taxonomic information gathered thus far about *Wy. smithii* in Mississippi.

Methods

Larval specimens were collected by aspirating water from pitcher plants with a turkey baster. Some larvae were fixed in hot water and preserved in 80% ETOH, while others were reared to the adult stage in the laboratory. Otherwise, no adult specimens were collected in this study. For vouchers, adults were glued to pinned paper points and labeled with collection information. All collections were made in the Grand Bay National Wildlife Refuge (GBNWR), which is an undisturbed area along the extreme southeastern coast of Mississippi containing mesic palustrine forests (slash pine flatwoods/ savannah with wiregrass, oak-mixed hardwood ridge bottom forest), wet palustrine forests (disturbed wet savannah habitat, old settlement wet forest/savannah habitat, wet pine – pond cypress savannah, wet slash, longleaf, pine savanna with broomsedge), shrub wetlands, inland freshwater marshes, swamp forests, upland maritime communities, estuarine fringe wetlands, and intertidal estuarine communities. All specimen identifications, adults and larvae, were confirmed by the fourth author. Specimens have been deposited in the Mississippi Entomological Museum, Mississippi State University, Starkville, MS, the Public Health Pest Management mosquito collection, Winston-Salem, NC, and the National Museum of Natural History, Smithsonian Institution, Washington, DC.

Results

Notes on the taxonomic status.—Since its original description (Coquillett 1901) and until 1947, populations ascribed to *Wy. smithii* from Florida to Canada were considered representatives of one taxon. Dodge (1947) altered this consensus when he described *Wyeomyia haynei* from South Carolina. Dodge separated *Wy. haynei* from *Wy. smithii* based primarily on the former having the following larval characters: (1) a small pair of dorsal anal papillae above the long ventral pair (*Wy. smithii* only has a ventral pair), (2) more comb scales, (3) seta 14-M equal to or smaller than 14-P (14-M is larger than 14-P on *Wy. Smithii*), and (4) setae 3, 4-X usually bifid (usually trifid on *Wy. smithii*). Dodge also described adults of *Wy. haynei* with silver scales on the mid-lobe of the scutellum while those of *Wy. smithii* are dark, but was unable to find differences in the male genitalia of the two species. Darsie and Williams (1976), comparing northern and southern specimens, re-examined the 4 larval characters identified by Dodge, and also found that setae 2-IV-VI would separate *Wy. haynei* from *Wy. smithii*. During the period 1947–77, taxonomists accepted the two species concept, although the male genitalia of the two species continued to be described as "indistinguishable" (Carpenter and LaCasse 1955). Two species in *Wyeomyia* having identical male genitalia is very unusual, as species of this genus typically have male genitalia with very distinct morphological characters. Darsie and Ward (1981) documented *Wy. haynei* as occurring in Alabama, Florida, Georgia, South Carolina, North Carolina, Virginia, and Maryland, while the distribution of *Wy. smithii* included more northern states, from Delaware west to Illinois and more northern states, and Canada. Unknown to Darsie and Ward, during the 1970s considerable research was conducted and published in non-taxonomic journals that focused on *Wy. smithii* as an inquiline of the purple pitcher plant host, *S. purpurea*. This research addressed the

taxonomy, biology, distribution, morphological variations, hybridization, competition with other inquilines of the pitcher plant, photoperiod, dormancy, diapause, altitude and latitude relationships, and other biological aspects of different populations of *Wy. smithii*. Bradshaw and Lounibos (1977) documented and studied representative specimens of 33 populations of *Wy. smithii* from Mississippi, Alabama, and Florida, more northern states in the U.S., to the Canadian provinces of Nova Scotia, New Brunswick, and Quebec. This represented the first record of *Wy. smithii* from Mississippi. They conducted laboratory cross-mating studies and found complete hybridization among the populations (northern, southern, high elevation, low elevation) that were crossed and backcrossed. The hybrids and backcrosses of the extremes (north-south, high-low elevations) were fully viable and expressed intermediate characters in the anal papillae, branching of setae 3, 4-X, expression of silver scales on the midlobe of the scutellum, and photoperiodic effects on initiation and depth of larval diapause along a cline from south to north, or from low to high elevation in North Carolina. They concluded that *Wy. smithii* is a polytypic species with three geographic races, i.e., *Wy. smithii* in the north and at high elevations in North Carolina, *Wy. haynei* in the mid-Atlantic and Georgia area as a geographic subspecies, and a newly recognized and more southern geographic race along the Gulf coast (Mississippi, Alabama, and Florida) with dorsal anal papillae nearly equal the length of the ventral anal papillae. Of interest, Bradshaw and Lounibos (1977) found high elevation populations in North Carolina that are morphologically identical to specimens of *Wy. smithii* found in northern states, while coastal North Carolina populations were identical to the geographical race called *Wy. haynei*. Upon learning of this published research, Ward and Darsie (1982) suggested more work (cross-mating studies) was needed to resolve the species status of *Wy. haynei*; however, the suggested cross-mating studies had already been accomplished in Bradshaw and Lounibos (1977). Darsie and Morris (2000) declared that *Wy. haynei* was a junior synonym of *Wy. smithii*. Now there is a consensus again; only a single species, *Wy. smithii*, is recognized as inhabiting the purple pitcher plant, *S. purpurea*, and also hybrids of *S. purpurea* and certain other *Sarracenia* species in North America. The Mississippi populations represent the Gulf Coast race of Bradshaw and Lounibos (1977); however, because of the south to north cline of morphological, biological, and physiological traits from the Gulf Coast to Canada, Bradshaw (unpublished personal communication) does not see a need for recognizing subspecies.

Biological notes.—Major mosquito publications for the North American fauna (Carpenter and LaCasse 1955, Wood et al. 1979) have commented on the lack of blood feeding by *Wy. smithii*, although the mouthparts are developed for blood feeding (Hudson 1970). Bradshaw (1980) resolved this enigma when he was bitten by *Wy. smithii* at low elevations in North Carolina and along the Gulf Coast. Furthermore, he observed a female taking blood from a box turtle in Florida. These observations led to further research where he determined that females from the northern and high elevation populations of *Wy. smithii* are always autogenous, while those from the low elevations in the Carolina Coast Plain and Piedmont and Gulf Coast populations are autogenous for the first oviposition, then anautogenous for later ovipositions. Accordingly, mosquito collectors should be alert for specimens attracted to light traps and coming to hosts for a blood meal.

Distribution and plant associations.—A total of 29 specimens of *Wy. smithii* were collected during this study (27

specimens in May and 2 specimens in Aug). Larvae were collected from one primary breeding site, a cluster of approximately 48 *S. purpurea* plants within a 5 m diameter circle. Later, another cluster of about 100 *S. purpurea* plants was located approximately 175 m from there, and larvae were observed living in those plants, but no collections were made. In addition, on July 26th, *Wy. smithii* larvae were observed in a cluster of *S. purpurea* × *S. alata* hybrids located approximately 100 m from the primary collection site. Nine days later, two larval specimens were collected from the hybrid plants and confirmed as *Wy. smithii.*

To date, *Wy. smithii* has been collected in only two locations in Mississippi, the GBNWR during this study (Jackson County, approximately 7 mi. east of Moss Point) and Movella, MS, reported earlier (Bradshaw and Lounibos 1977; George County, approximately 15 mi. south of Lucedale). There is one other unpublished collection report of 7 adult specimens by a mosquito control technician using CO_2 baited CDC light traps in a pitcher plant field in Gautier, MS (Jackson County) during a West Nile mosquito survey. Numerous attempts by the senior author to verify this finding have proven unfruitful. If confirmed, the Gautier site would be the most western report of *Wy. smithii* in the southern United States.

Effects of a controlled burn.—The entire 960 acre field containing the pitcher plants with *Wy. smithii* underwent a controlled burn by refuge personnel on April 14, 2005. A few water-filled *S. purpurea* leaves survived the burn, but were badly damaged. No living *Wy. smithii* were seen in any leaves a day after the burn. The area was observed weekly for new pitcher plant growth and subsequent repopulation of the leaves with *Wy. smithii.* Regrowth of pitcher plant leaves occurred within 2 weeks. All new patches of over three or more individual plants were there prior to the fire. No mosquito larvae were seen in the new leaves for approximately 16 weeks (July 25th), after which leaves were thoroughly repopulated. How and from where the pitcher plants were repopulated is unknown. No other patches of *S. purpurea* have been found in the immediate area.

Effects of a hurricane.—Hurricane Katrina hit the coasts of Louisiana, Mississippi, and Alabama on August 29, 2005, causing widespread catastrophic destruction. The 145 km Mississippi coastline was especially hit hard, although power outages and wind damage occurred as far as 322 km inland. The hurricane storm surge inundated many areas along the Mississippi gulf coast, and virtually 100% of the area south of Highway 90 in the proximity of the Grand Bay National Estuarine Research Reserve (GBNERR) was hit with a 6 m storm surge, recorded by GBNERR personnel (S. Christine Walters, personal communication). The GBNERR is partially contained within the GBNWR. The pitcher plant field in this study was located south of Highway 90 and was flooded by the surge. There was direct observation by a GBNERR staff member of approximately 1 m of water covering the entire pitcher plant savannah on the afternoon of the storm (Chris May, personal communication). Interestingly, neither the pitcher plants nor the mosquito larvae were apparently harmed by this inundation with salt water. Two visits to the site after the hurricane (Sept. and Nov.) revealed numerous *Wy. smithii* larvae living inside the leaves of *S. purpurea.*

Conclusions

The Gulf Coast race of *Wyeomyia smithii* extends into southeastern Mississippi where it is associated with populations of the purple pitcher plant

and a hybrid between the purple pitcher plant and the pale pitcher plant. Taxonomic analysis of Mississippi *Wy. smithii* does not support naming the Gulf Coast race a subspecies at this time. Based on data from one controlled burn, burning pitcher plant fields apparently decimates pitcher plant mosquito larvae residing in the plants, but repopulation occurs within weeks or months. Preliminary evidence suggests that short-term exposure to salt water from the tidal surge of Hurricane Katrina did not affect pitcher plants or their mosquito larvae.

Acknowledgments

Bill Bradshaw, University of Oregon, provided information and helpful comments concerning this manuscript. Christine Walters and Chris May, Grand Bay National Estuarine Research Reserve, provided information about the effects of Hurricane Katrina on our study site.

Literature Cited

Armbruster, P., W. E. Bradshaw, and C. M. Holzapfel. 1998. Effects of postglacial range expansion on allozyme and quantitative genetic variation of the pitcher plant mosquito, *Wyeomyia smithii*. Evolution 52: 1697–1704.

Bradshaw, W. E. 1980. Blood-feeding and capacity for increase in the pitcher plant mosquito, *Wyeomyia smithii*. Environmental Entomology 9: 86–89.

———. 1983. Interaction between the mosquito *Wyeomyia smithii*, the midge *Metriocnemus knabi*, and their carnivorous host *Sarracenia purpurea*, pp. 161–189. *In* Frank, J. H. and L. P. Lounibos, eds. Phytotelmata: Terrestrial Plants as Hosts for Aquatic Insect Communities. Plexus Publishing, Inc., Medford, NJ.

Bradshaw, W. E. and L. P. Lounibos. 1977. Evolution of dormancy and its photoperiodic control in pitcher plant mosquitoes. Evolution 31: 543–565.

Carpenter, S. and W. LaCasse. 1955. Mosquitoes of North America. University of California Press, Berkeley, CA. 360 pp.

Coquillett, D. W. 1901. Three new species of Culicidae. Canadian Entomologist 33: 258–260.

Darsie, R. F. Jr. and C. D. Morris. 2000. Keys to the adult females and fourth-instar larvae of the mosquitoes of Florida. Florida Mosquito Control Association, Technical Bulletin Number 1(revised): 1–159.

Darsie, R. F. Jr. and R. A. Ward. 1981. Identification and Geographical Distribution of the Mosquitoes of North America, North of Mexico. Mosquito Systematics Supplement 1: 1–313.

———. 2005. Identification and Geographical Distribution of the Mosquitoes of North America, North of Mexico. University Press of Florida, Gainesville.

Darsie, R. F. Jr. and R. M. Williams. 1976. First report of *Wyeomyia haynei* in Georgia, with comments on identification of larvae. Mosquito Systematics 8: 441–444.

Dodge, H. R. 1947. A new species of *Wyeomyia* from the pitcher plant. Proceedings of the Entomological Society Washington 49: 117–122.

Hudson, A. 1970. Notes on the piercing mouthparts of three species of mosquitoes viewed with the scanning electron microscope. Canadian Entomologist 102: 501–509.

King, W. V., G. H. Bradley, C. N. Smith, and W. C. McDuffie. 1960. A handbook of the mosquitoes of the southeastern United States. U.S. Department of Agriculture, Washington, D.C., Agricultural Handbook No. 173, 188 pp.

Naczi, R. F. C. and E. M. Soper. 1999. *Sarracenia rosea* (Sarraceniaceae), a new species of pitcher plant from the southeastern United States. Sida 18: 1183–1206.

Ward, R. A. and R. F. DarsieJr. 1982. Corrections and additions to the publication, Identification and geographic distribution of mosquitoes of North America, north of Mexico. Mosquito Systematics 14: 209–219.

Wood, D. M., P. T. Dang, and R. A. Ellis. 1979. The Mosquitoes of Canada. Canadian Department of Agriculture, Biosystematics Research Institute, Publication Number 1686 (part 6), 390 pp.